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Discussion Paper on Liquid Fuel Options

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FOREWORD

We Canadians approach our energy future from a position of inherent strength. Unlike many other industrial nations, we are a net supplier of energy to the world, not a net importer; we produce in Canada more energy than we consume. This has placed us in the special position where we have a number of energy alternatives for the future and the time to choose wisely among them.

Among the most important sources of energy are liquid fuels—those that come from oil and natural gas. While we have a large surplus of natural gas, we remain dependent on unreliable foreign sources for a troublesome amount of oil. Our first goal is to wipe out *net* oil imports within a decade, and in moving actively towards this energy-management objective it will be essential to consider all realistic near-term options for the production, use and distribution of liquid fuels.

In the longer term, our goal is to encourage the development of our resources and technology, to ensure a continuing supply of liquid fuels appropriate to Canada's needs and opportunities and consistent with our objectives for industrial growth, foreign trade and environmental quality.

I have asked my Department to prepare this discussion paper to promote full public consideration of the opportunities and problems associated with liquid fuel options of two kinds:

- Changing the way we refine and use fuels from current sources—for example, diverting propane exports to domestic markets, shifting from gasoline to diesel fuel, diverting heavy fuel oil exports, and changing fuel specifications and engine design.
- Developing new sources of fuel—for example, alcohol fuels, liquids from coal and natural gas, fuels from "synthesis gas", and hydrogen as a transport fuel.

Both approaches are assessed in harmony with three essential energy strategies: energy conservation, possible substitution of more plentiful fuels for scarce liquid fuels, and development of new sources of oil supply.

The paper also summarizes the various liquid fuel options by their cost, limiting factors, and potential contribution to the 1990 energy picture.

My objective in publishing this paper—as with the earlier paper on coal—is to encourage public debate on the energy options that lie ahead.

I have asked my Department to elicit public response to these and other papers in the series.

Marc Lalonde

MARC LALONDE
Minister
Energy, Mines and Resources Canada

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INTRODUCTION

Liquid fuels are a familiar and necessary part of almost every daily activity in this country. The liquid fuels used by Canadians today come mostly from oil, some from natural gas. Fuels refined from crude oil include gasoline for cars and trucks, diesel oil for rail, marine, farm and highway uses, fuel oil for heating and industrial use, and other fuels such as kerosene. A small quantity of liquids is extracted from natural gas; these tend to be lighter fuels that vapourize readily such as propane and butane. They are used primarily in special applications, such as cooking, crop drying and indoor vehicles (in skating rinks and warehouses), where low combustion emissions are a major asset.

Liquid fuels are important because they are so convenient to use. They are easy to store, cheap to transport and highly concentrated. A litre of gasoline packs an enormous amount of energy for its size. It is for this reason that liquid fuels provide virtually all our transportation energy in Canada. With the exception of some increasingly popular forms of recreation, such as cycling, sailing, running and strolling, oil products are used for moving goods and people by land, sea or air. By no means is all our oil used in transportation, but the share is growing.

Liquid fuels are of particular importance to Canada right now for another reason: we don't produce enough of them to meet our needs. This is not true of energy generally as illustrated in Figure 1. Other fuels are in surplus supply in Canada, fuels such as coal, electricity and natural gas; and Canada's total exports of energy exceed her imports. But for liquid fuels, the opposite is true. Net imports of oil excluding LPGs are currently about 300 Mb/d (thousand barrels a day). This deficit is of great concern to federal and provincial governments in Canada because foreign oil has become very expensive and the supply may not always be secure.

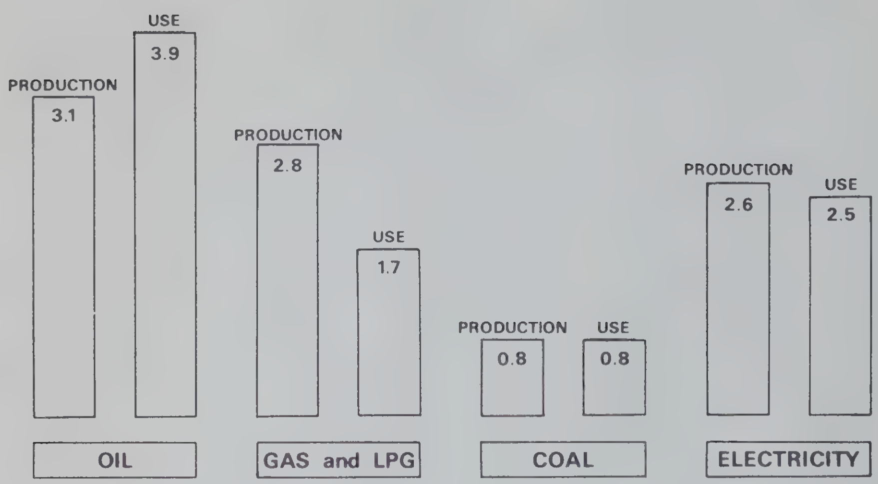
Current federal energy policy directed at assuring Canada sufficient liquid fuel supplies for the future has emphasized five major policy goals:

- Stimulate domestic oil supplies;
- Make supplies of foreign oil to Canada more secure;
- Conserve energy, especially oil, through more efficient use;
- Substitute non-liquid fuels for oil in uses where liquid fuels are not essential; and
- Provide contingency plans for temporary shortages of oil products.

FIGURE 1

ENERGY PRODUCT AND USE IN CANADA 1978

(10^{18} JOULES)



A sixth policy element is being developed, one aimed at identifying liquid fuel options and outlining the types and sources of liquid fuels that will be available in Canada in the future.

- Identify and pursue opportunities to make *new* liquid fuels in Canada and opportunities to change the way *current* fuels are produced and used.

Opportunities to make new liquid fuels are of considerable interest in Canada. They involve new fuel sources, like gas, coal, wood and garbage; the fuel products might be quite novel, such as methanol, or reasonably familiar, such as gasoline. For example, both methanol and gasoline could be made from coal in Canada through different processes.

The other set of liquid fuel opportunities may be of less popular interest, but is an active subject of study by fuel refiners and consumers. These opportunities involve different ways to produce or use current fuels, that is, fuels from crude oil and natural gas liquids. Examples include the production of lower quality, less exacting motor fuels which can be drawn from a broader fraction of the crude oil barrel than today's gasolines and diesel fuels; these are called broad-cut fuels and may yield more litres of fuel for less money from each barrel of oil. Another example is the use of an existing fuel—propane—in new applications such as on-the-road vehicles.

The examples above all involve transportation fuels, but this need not be so. There are many opportunities to use new fuels in stationary applications, and often the problems of converting to new fuels are easier for such applications than for the more complex transportation system involving countless engines, fuel tanks and fittings, and filling stations. On the other hand, stationary applications are candidates for conversion to non-liquid fuels, the fourth policy element of the six listed previously. The portability of a liquid fuel, essential in most transport applications, is not critical in stationary applications. In many cases it may be cheaper and more efficient to convert the equipment from oil to a non-liquid fuel such as gas, coal or wood than to convert the gas, coal or wood to a liquid fuel.

Nevertheless, liquid fuels will remain an essential energy form in Canada, having prime value where energy must be moved, stored or highly concentrated, or where other energy forms are not available. Some of the liquid fuel options described in this paper might be very attractive over the next 10 or 20 years, particularly if we could plan complementary changes in the production and use of current liquid fuels, to secure a match between the fuels available and the fuels required. For example, if gasoline from coal were to enter the market, it might be desirable to reduce the yield of gasoline from crude oil. A broad liquid fuels policy will help us take advantage of new fuel opportunities and guide the adjustments that may be needed in the overall liquid fuels system. It will provide targets to assist governments, fuel producers and fuel users in Canada with their longer-term planning: What liquid fuels will be required in the future and for what uses? How are these requirements to be met and from what sources of fuel? What types of liquid fuels will be available in Canada, and what actions is the Government taking to encourage these fuels?

The federal government has been studying liquid fuel options to determine how attractive they might be and what types of difficulties or barriers stand in their way. The Government is anxious to encourage discussion of these options with provincial governments, fuel producers and users, and the public to identify the need for federal action and policy. This paper describes some of Canada's liquid fuel options as a background for those discussions.

THE CURRENT OUTLOOK FOR LIQUID FUELS

There is considerable uncertainty about future requirements for oil in Canada and the domestic supplies that will be forthcoming to meet them. Requirements are expected to climb slightly or even moderately, production of conventional oil will decrease markedly, and our supplies of synthetic oil from tar sands and heavy crudes should increase slowly. Major efforts to develop tar sands and heavy oils, possibly with some oil from frontier areas, are projected to make Canada ultimately self-sufficient in oil provided we keep our national appetite for oil from increasing too quickly. In the meantime, we face the prospect of a possible decade of reliance on foreign and possibly insecure sources of oil.

Another related concern is a lack of balance between the liquid fuels available and those required. Besides the fact that requirements exceed supply in total, the two are unbalanced with respect to:

- *Regions*—most of Canada's liquid fuels are produced in the western provinces. The heaviest requirements are in eastern Canada. It may not always be desirable to move a fuel product across the country from one region where there is a surplus to another where there is a need.
- *Fuel products*—the quantity of each liquid fuel product refined in Canada doesn't always match the national requirement for that product. For example, we currently produce more LPGs and more heavy fuel oil than we need, and we project a growing difficulty in producing enough diesel oil and jet fuel, for which demand is increasing relative to other products such as gasoline.

Of course these projections are based on trends that may alter. For example, product imbalances will depend on many factors such as the types of crude feedstocks available, the ability of refineries to adjust to changing crude supply and product requirements, and changes in consumer fuel purchasing habits. Many of these factors might be influenced by provincial and federal government action. The federal government has begun encouraging refineries in eastern Canada to adjust to the increasing surplus of residual oil being produced. The question dealt with in this paper is what are the liquid fuel options and corresponding Government actions that might reduce the oil deficit and/or create a better liquid fuel balance by region and by product.

LIQUID FUEL OPTIONS FOR THIS CENTURY

There is no lack of ideas for new fuel options for Canada. Suggestions are frequently being made to industry and governments on the best fuels for Canada, and parallels are drawn with fuel developments in other countries. In the past few decades, oil has been a great homogenizer of energy use patterns; cheap to produce and cheap to transport, it became available everywhere and displaced local energy resources and fuels in many applications throughout the world. Petroleum-based fuels achieved a high degree of world-wide uniformity. Today oil is no longer cheap or plentiful. Alternative fuels that are beginning to emerge differ from country to country, depending on energy requirements and resources available. Gasoline will begin to be blended differently in countries that choose to produce some liquid fuels from coal or wood; it might be replaced by a completely new fuel in certain countries. In a country as broad and diverse as Canada we can expect some variety within our own boundaries, with regional differences influencing what fuels are available and practical.

With an increasing variety in fuels, new engines are being developed. A propane engine has been produced in Switzerland, an alcohol engine in Brazil. In a world of diverse liquid fuels, two predominant types of power plants and vehicles might emerge: vehicles in a restricted region requiring a specific fuel for a special engine, and vehicles with fuel-tolerant engines which are not restricted by fuel availability. Microprocessors are being developed today which can sense fuel differences and adjust engine operation when necessary.

With this view of the future, it is quite appropriate to encourage the ideas for new fuels which are being put forward in Canada today. Some of them will take hold. It may be too early yet to make a choice among options, but it is certainly too early to close any off. We must accept ideas and begin the process of trying them out, learning about them and evaluating them. Evaluation in the social context is difficult business, but one might begin by identifying the effects of introducing an option. One important effect might be to reduce our imports of foreign oil, but there are others. For example, we might pursue a fuel option to:

- Add to the supply of domestic liquid fuels, reducing imports;
- Lower the cost of fuel production;
- Increase the variety of fuel sources, and thus the resilience of our fuel supply;
- Change fuels to match changing fuel sources or changing engine technology;
- Broaden the regional base of fuel production; or
- Develop industrial and export opportunities for Canada.

These effects may be quite important in decisions on whether to encourage a new liquid fuel. It is also important, in assessing the value of investments in liquid fuels, to consider and compare liquid fuel options with the other elements of energy policy that could contribute to reducing oil imports and improving the liquid fuels balance. In particular, liquid fuel options must be assessed in harmony with other options:

- *Energy conservation*—in many areas it is still true that it costs less to save a barrel of oil than to produce one. Investing in insulation to "keep the heat in" is an example. Reducing vehicle speeds on the highway may be another. Moreover, a barrel saved may be more secure than a barrel produced.
- *Substitution*—natural gas, electricity, and also solid fuels such as coal and wood can displace oil.
- *New oil supply*—sources of new oil include enhanced recovery from conventional oil reserves, and the vigorous development of unconventional oil from tar sands, heavy oils, frontier and east coast oil fields. These options may hold some of the cheapest barrels of new liquid fuels available to Canadians, but major constraints of manpower, capital and technology limit how fast we can develop them.

The remaining sections of this paper discuss new liquid fuel options in the context of the various considerations mentioned above. As described in the Introduction, the options are grouped in two different approaches: changing the refining and use of fuels from current sources and developing new sources of fuels.

CHANGING THE REFINING AND USE OF FUELS FROM CURRENT SOURCES

Diversion of Propane Exports to Domestic Markets

This opportunity is one of finding new uses for an existing fuel. Canada produces 130 Mb/d propane of which only about half is required. Our current exports of propane exceed 65 Mb/d, and this surplus is expected to continue throughout the decade. There are several *domestic markets* that could absorb this propane:

- *Heating oil*—considerable quantities of propane could be delivered to heating oil markets in central and eastern Canada by 1985, as much as 30 Mb/d according to a recent industry study. Natural gas is also aimed at these markets, but in some locations it might be cheaper to displace heating oil with propane than to run the expense of a gas pipeline distribution system. This might be true in sparsely-populated regions, or where local geology makes pipe-laying very expensive. Relatively little oil is used for residential heating in the west, where natural gas and, to a much lesser extent, propane already have substantial penetration.

- *Vehicle fuels*—propane is an excellent vehicle fuel. Gasoline powered vehicles of today could run effectively on propane with a few changes, involving primarily the addition of a propane storage tank and modification to the carburetor and fuel system. Modification of a gasoline engine would cost between $1,200 and $1,500. Some of the advantages of propane include greater combustion efficiency (an engine using propane rather than gasoline needs about 10% less energy), lower service costs and a longer engine life by two or even three times. Propane is recommended for fleet use, particularly trucks, vans and taxicabs because these vehicles tend to have high usage and are often centrally-fuelled. The current retail distribution of propane is somewhat limited. One estimate is that at least 25 Mb/d propane could be consumed by vehicle fleets in Canada by 1990. The popularity of propane as a vehicle fuel in many countries is already substantial. Some interesting industrial opportunities arise for Canada in propane conversion—parts manufacture (tanks, carburetors, etc.) and the production of special propane engines, which could require up to 30% less energy than a gasoline engine to do the same work.

- *Petrochemicals*—propane could be an acceptable feedstock for a number of processes in a growing Canadian petrochemical industry. For example a plant producing ethylene and propylene based on the cracking of propane might consume 40 Mb/d.

- *Enhanced oil recovery*—some experiments are underway in western Canada using propane for miscible flooding in oil reservoirs, but there are other chemicals such as ethane and carbon dioxide, that might be more cost-effective in this use.

There is considerable interest by government and industry in new markets for propane. The propane producers themselves would like to sell more of their product into domestic markets, perhaps anticipating a possible world-wide propane surplus in the coming decade. Some new markets appear fairly easy to reach, and there are signs that with modest encouragement they will develop. The use of propane in vehicle fleets is an example. Other markets are not yet commercially attractive and would require significant encouragement. Some of the *barriers* that are believed to impede certain new domestic markets are:

- *Inadequate propane transportation facilities*—most (105 Mb/d) of our propane is produced in western Canada, but most of our energy is consumed in the east. About 40 Mb/d of western propane already moves to Ontario, and an expansion this year of the processing facilities at Sarnia will permit an increase in this supply to about 50 Mb/d. Most of the propane that does reach Ontario is exported to the United States; local transportation and distribution facilities in the east would have to be expanded considerably if all of these exports were to be redirected to Ontario and Quebec markets. The movement of propane in substantial quantities requires pipelines; rail movements are expensive and may be unsatisfactory for large continuing volumes. There appears to be considerable private investment interest in the necessary pipelines, as long as governments are prepared to act to make major new flows to propane commercially attractive. However, we must also recognize that alternatives exist to major additional west-east propane shipments. We might develop new western markets for the propane that is in surplus supply there, or arrange to swap this propane south in return for deliveries to Atlantic Canada from the large propane terminals on the east coast of the United States.
- *Consumer acceptance of propane*—propane has a great many applications; but consumers are often unaware of the range of opportunities for its use, regarding propane as a "special" fuel only. For example, few vehicle fleet operators in Canada have seriously considered propane conversion. Yet in many countries of the world propane has widespread applications in vehicle fleets. Interest in this use in the United States is expected to increase markedly during the next few years, partly because of concerns about gasoline availability. Governments can increase the acceptance of propane in motor vehicles through demonstration in government fleets and through tax incentives for investment in propane conversion. In Canada, this is beginning to happen, with the recently announced demonstration programs in the Department of National Defense and several provincial governments.

- *Domestic propane prices*—the most significant barrier in eastern Canadian markets is price. The price of propane in eastern Canada is higher than the domestic price of the oil products it might displace. This is not generally true in western Canada, and the difference reflects the relatively high costs of transporting propane from the west. Although propane can compete with oil in certain markets in western Canada, it has been losing market share to natural gas, which is traditionally cheaper. The result of this price disadvantage has been no growth in the domestic propane market over the past several years, and a persistent propane surplus. At today's world oil prices, continuing propane exports could be a losing proposition for Canada. We are importing oil in Montreal from which gasoline costs \$42 a barrel and exporting the same amount of energy from Sarnia (1.4 barrels of propane) for \$25.

The major policy difficulty facing the federal government regarding new markets for propane is a regional one. Because the present cost and availability of propane differ markedly from region to region, the Government action needed to encourage domestic use of propane depends on where in the country the markets are to be developed. Propane is currently in surplus supply in Ontario (25 Mb/d surplus) and in the western provinces (40 Mb/d surplus), and is exported from these regions to the United States and to Japan. Ontario and more than one western province have expressed an intention to find uses for their propane surplus, with vehicle applications being a prime target. Propane can already compete with gasoline in Alberta and Saskatchewan because its price, for the equivalent energy, is less. In Ontario propane can compete as a motor fuel although its cost is higher, because a road tax exemption for alternative fuels gives propane a price advantage at the pump. Under the circumstances, the federal government may have to do relatively little to expand propane uses in these regions. Appropriate actions might be steps to assist consumers with the cost of conversion to propane, to assure new customers that propane will continue to be available in their region at competitive prices, and to provide adequate safety codes for propane distribution and vehicle use.

Currently, there is no net surplus of propane in Atlantic Canada and Quebec, and more substantial federal action would be required to make propane available to these regions at competitive prices. However, this situation may change within the next few years. A growing world surplus of propane is projected and could result in barrels of propane tied to crude oil imports to eastern Canada. Moreover, oil and gas development off the east coast may bring abundant supplies of propane to the Maritimes. Studies are continuing to seek ways to expand current propane supplies and markets in Quebec and the Maritimes to prepare for these possibilities.

The Shift from Gasoline to Diesel Fuel

The NEB forecast of fuel requirements shows a strong growth in diesel fuel relative to gasoline. The trend to a lower gasoline-distillate ratio reflects a number of developments, among them growth in commercial truck traffic and equipment use, the increasing fuel efficiency of gasoline engines during the first half of the decade, and some penetration of diesel engines into the light truck, passenger car and farm equipment markets. Diesel engines have some advantages because of better fuel economy, particularly in cold weather. But there are some drawbacks too. If the diesel population grows, particulate emissions may become a health hazard. And the fuel requirements for high-speed diesel engines of the type being installed in lighter vehicles may be fairly exacting, especially in Canadian winters. There are indications that we will have difficulty in Canada producing enough acceptable diesel fuel, unless additional middle distillates are freed from present heating uses and diesel quality requirements are relaxed considerably. This difficulty may be compounded as more of our crude oil becomes synthetic (from tar sands) or heavy (both domestic and imported); the middle distillates from these crudes do not readily yield a diesel that would meet current fuel standards.

Canada should examine how far the diesel trend could continue without a "squeeze" on the fuel. Each barrel of oil yields only a limited amount of acceptable diesel fuel, synthetic crudes even less. More could be made but at considerable cost. The advantages of the diesel engine in fuel economy may then be offset by the increased energy and economic cost of fuel manufacture. Moreover, the fuel economy of gasoline engines may soon improve sufficiently to seriously challenge the principal advantages of small diesel engines.

The long-term availability of diesel fuel may be more of concern to Canada than to the United States, where oil shales are expected to yield diesel fuel more cheaply than tar sands. For the time being, Canada should accept the current gradual trend to diesel engines, while at the same time beginning to examine the longer-term implications of a continuing or accelerated trend in this direction.

Diversion of Heavy Fuel Oil Exports

The production of heavy fuel oil in Canada by the middle of the decade would be significantly greater than the projected demand for this fraction of the barrel, without substantial refinery adjustments or new facilities to upgrade heavy crude and residuals. The share of heavier crudes in both domestic and imported crude streams is forecast to increase. Without upgrading, a large exportable surplus of residual fuel oil could be produced, and oil imports would have to increase to meet our needs for other products.

The federal government and industry have been studying ways to make these refinery adjustments, and the Government has announced a series of

agreements to place upgrading facilities in several large refineries, and to have Petro-Canada study the feasibility of a central facility in the Montreal area to upgrade residual oil produced there. In total, these installations could make better use of about 140 Mb/d of residual oil, reducing product exports and crude imports.

Changes in Fuel Specification and Engine Design

Canada faces a number of opportunities to depart from fuel specifications and engine designs that we have largely "inherited" from corporate and government decisions in the United States. These decisions have not always produced the best fuels and vehicles for Canada's own resources, climate and needs, and there are indications that they may be even less appropriate in the future. During the 1980s, crude oil feedstocks and emissions standards in Canada are both expected to differ significantly from the United States. Some opportunities to respond to these differences are:

- *Changes in the quality and boiling point range of jet fuels and diesel fuels*—it is possible to a limited extent to lower the flash point or boiling point range of jet and diesel fuels without major problems. Indeed the addition of lighter components in diesel fuel might improve cold starting. These broad-cut fuels would increase refinery flexibility and might lower fuel costs. For example, the increased use of more broadly specified jet fuels, such as Jet A-2 and Jet B, could make available more of the kerosene needed for diesel fuel manufacture. Fuel quality changes might also be considered. Jet fuel specifications limit "aromatic" content, and cetane specifications have the same effect, indirectly, for diesel fuel. Current work in Canada and the United States is aimed at identifying how much change in these specifications could be tolerated. The work is especially important for Canada whose crude feedstocks, particularly synthetic crudes, are projected to be increasingly aromatic. This characteristic has octane advantages in gasoline manufacture but is not a benefit for diesel and jet fuel.

- *Examination of the use of leaded gasoline*—unleaded gasoline is used in the United States because lead additives would foul the catalytic converters needed by current vehicles to meet emission standards. In *Canada* we buy the same vehicles that are made for United States markets and most of these use unleaded gas. However, lead is an inexpensive and energy-efficient octane booster for gasoline. The cost and energy requirements of manufacturing *unleaded* gasoline are relatively high, especially premium unleaded which current engines, adjusted for maximum fuel economy, tend to require. It has been estimated that Canada could save a significant amount of refining energy, perhaps 25 Mb/d by 1990 when a large percentage of our

gasoline could be unleaded, if we could produce and sell vehicles that meet the domestic environmental and emission standards with leaded gasoline and appropriate control technologies.

- *The development of appropriate engines*—engines appropriate to Canada's fuels and needs should be encouraged, especially where they build upon development work already underway in Canada. For example, current work in several countries including Canada, on high-compression fuel-efficient engines might create a market for high octane fuels such as propane, alcohols and gasolines from aromatic crudes. A number of options are available to Canada for boosting the octane rating of its gasolines, including the addition of methanol-derived organic compounds such as ethers. Another interesting, but in some ways opposing development is the fuel-tolerant engine. An example is the Texaco controlled combustion system (TCCS), an engine that tolerates a wide range of fuels with no cetane or octane demand, and promises as much as 40% improvement in fuel economy over current gasoline engines.

DEVELOPING NEW SOURCES OF LIQUID FUELS

Hydrocarbon Fuels Manufactured from Synthesis Gas

A number of fuel options pertain to the manufacture of new fuels. Among the earliest available of new fuels are those that could be made from "synthesis gas", a mixture of hydrogen and carbon monoxide. There are many sources of synthesis gas, including natural gas, coal, wood, peat, biological wastes and garbage. All of these sources are in abundant supply in Canada. Synthesis gas appears as an intermediate in several industrial processes such as the reduction of iron ore. Industry and the research community should take a much greater interest in the growing number of new processes and developments in the chemical synthesis of fuels.

Many processes are already well-known and in current practice; examples are the Fischer-Tropsch synthesis, and the synthesis of methanol and ammonia. Of particular interest as a near-term fuel option is Fischer-Tropsch because this process can produce hydrocarbon fuels similar to the gasolines and diesel fuels we use today. It is currently practised on a large scale in South Africa under the name "SASOL", and involves the production of a wide range of products from coal, including a significant portion of the country's gasoline requirements. A version of this process could be adapted to Canada's coal resources and fuel needs, and could provide us with 30 Mb/d of transport fuels as early as 1986, perhaps twice that much by 1990. This process is only about 40% energy-efficient at this time, and the fuels would be quite expensive. Product cost estimates occupy a broad range, from \$45 to \$65 a barrel oil equivalent (1980 dollars), depending upon factors such as plant location, coal quality and markets for by-products. The Fischer-Tropsch technology is an evolving one and may become more attractive in the future. It may hold some special advantages for Canada, for example, the availability of natural gas as a source of hydrogen and opportunities to market carbon dioxide for petroleum recovery.

A newer process recently patented by the Mobil Corporation may be more attractive because it produces fewer products than Fischer-Tropsch synthesis by employing a more specific zeolite catalyst at improved energy efficiencies. The Mobil process yields a high quality gasoline and a smaller quantity of LPGs. The process can be based upon coal or natural gas or both, and methanol is an intermediate product. New Zealand intends to adopt this process to convert some of its natural gas to 13 Mb/d of gasoline. A plant in Canada based on natural gas could be operating by 1987 with output at 30 Mb/d of gasoline. A coal-based plant would take slightly longer to engineer.

The cost of Mobil gasoline based on Canada's inexpensive coals would be about \$45 a barrel oil equivalent. If the feedstock is natural gas, the product

cost would depend on the value of the natural gas. Gas at \$4/Mcf (thousand cubic feet) would yield gasoline at \$55 a barrel oil equivalent; at \$2/Mcf the gasoline would cost \$40. While \$4 may be an appropriate economic value for gas as a marketable commodity, there may be gas "beyond economic reach" in the Arctic or elsewhere which can not be delivered to market, but which could perhaps be brought to the surface for less than \$2/Mcf and converted to gasoline before transport to market.

There are a number of quite exciting developments in advanced synthesis processes in laboratories in the United States, France, West Germany, Great Britain, Japan and elsewhere that promise significant improvement in the state-of-the-art technology by 1990. Governments and industry in Canada are aware of this work and are in touch with the research communities involved, but we are only starting to sponsor research of our own in the field.

Direct Liquids Produced from Coal and Biomass

Another way to produce liquid fuels from coal, wood, seeds and other organic materials is through direct hydrogenation at high temperature and pressure in the presence of a catalyst. This process is more energy-efficient than synthesis but is less advanced technologically. A great deal of research and development has been applied to the liquefaction of coal in the United States, Great Britain, West Germany, Japan and elsewhere, and demonstration of several techniques is expected very soon. However, commercial production of direct coal liquids is probably still a decade away.

The refining of large quantities of coal liquids would require new refineries or substantial adjustments to existing ones. Initially, small quantities of coal-derived liquids could be blended with crude oil feedstock with few problems. Coal liquids are very aromatic and could be refined through hydrotreating to high-octane gasoline, heating oil and boiler fuel. The production of a satisfactory diesel fuel would require more hydrogen and considerable processing, and it would be quite expensive. However, there may be a possibility of gaining economic and technical advantages in the production of a broad range of transport fuels through the joint refining of coal liquids with crude oils that contain a higher quality diesel fraction. In the United States, crude coal liquids are expected to cost about \$40 a barrel oil equivalent.

In Canada, coal liquids might be a bit cheaper because of the availability of natural gas. The use of natural gas to supply the necessary hydrogen, rather than generate it internally in the process, may lower the cost by several dollars. Even so, coal liquids are likely to remain more expensive than crude oil from tar sands. However, another opportunity that could lower the cost of coal liquids is the co-processing of coal and tar sands. Work that is underway on this option at the Canada Centre for Mineral and Energy Technology has revealed that coal helps to catalyze the upgrading of the

bitumen. There are other ways to involve coal with tar sands operations, for example, as a source of energy for steam-raising which is already scheduled in one plant. Such methods may turn out to be the cheapest (albeit indirect) routes to liquid fuels from Alberta coal. These opportunities are discussed in a companion paper on coal.

Outside of Alberta, coal liquids may be attractive in the next decade as a competitive regional source of fuels. However, even by 1990 it is unlikely that Canada could have progressed beyond its first commercial coal liquids plant, producing perhaps 60 Mb/d. Before that, coal may form part of our liquid fuel supplies directly, in a finely-powdered mixture with fuel oil. Demonstrations of coal-oil mixtures with up to 40% coal are underway in Atlantic Canada, where it is estimated that 15 Mb/d of oil could be saved by converting 11 utility boilers to these mixtures.

Other than the work on the co-processing of coal and bitumen and on coal-oil mixtures, Canada has little technology of its own; but the Government has encouraged and established programs to assess Canadian coals and to examine liquefaction technologies at the bench scale. Canada might "borrow" foreign technology to liquefy domestic coal, perhaps in return for some of the product. Indeed, there is evidence that other countries are already eyeing Canada's coal as a relatively secure and economically attractive source of liquid fuels, and Canada may be soon obliged to respond to foreign proposals to provide technology and capital in return for an "offtake" of coal liquids. This has been discussed in a companion paper recently released and entitled *Discussion Paper on Coal.*

Vegetable oils and other liquids from the hydrogenation of biomass (organic) materials are of growing interest in a number of countries as a longer-term option. There are some research projects in this area in Canada, but no significant potential exists for direct liquids from these sources before 1990.

Ethanol and Higher Alcohols

Small quantities of ethanol and butanol could be produced from the fermentation of low value cull crops and industrial wastes (food processing, pulp mills) for use as a fuel in Canada. One pulp mill in Ontario has been producing ethanol for some years, but it is sold to industrial markets. At current world oil prices, industrial markets at 40¢ a litre provide a higher value for ethanol than fuel markets could. However domestic industrial markets are not large (80 million litres a year) and are already served adequately through ethylene-based ethanol production. Therefore, additional quantities of ethanol from fermentation would seek fuel markets or export opportunities.

The production of ethanol from wastes could be attractive in situations where environmental credits were available. It is known that at least one pulp mill and one large starch producer in Canada are considering ethanol produc-

tion for this reason. At costs of about 25¢ to 30¢ a litre, up to 500 million litres of ethanol could be available from such sources in 1990. If care is taken in the formulation of gasoline, the ethanol could be blended with gasoline in the summer in a 10% mixture without major problems ("gasohol"). Depending on the octane number of the base gasoline, each litre of ethanol so blended could displace between 0.7 and 1.0 litres of gasoline. Options to use straight ethanol as a fuel also exist, both in vehicles and stationary applications. In various ways, ethanol produced from wastes could displace up to 8 Mb/d of oil by 1990, at costs of between $40 and $50 a barrel (1980 dollars). This would be a small but benign energy contribution. It is not cheap, but it does have regional, environmental and social appeal.

There are some additional areas of interest that bear study and are candidates for major technical advances. One is the selective fermentation to butanol as the major alcohol product. Butanol contains more energy and is much more compatible with gasoline than ethanol. Another is improved fermentation technology, including the production of alcohols through the hydrolysis and fermentation of cellulose. This technology would greatly expand the feedstocks available in Canada for fermentation ethanol, for example, garbage, wood, wood wastes and agricultural residues. It can be done today, but it is too expensive. A breakthrough in costs is believed possible and could lead to some production by the end of the decade. A third area is the technology of separating alcohol from water (currently distillation). Alcohol must be anhydrous to blend with gasoline, and distillation consumes considerable energy. Here again, a great deal of imaginative thought is now being given to the separation of these liquids. With all this technical interest, fermentation ethanol and higher alcohols could offer a modest fuel contribution from selected low-value feedstocks within the present century.

Other ethanol options have been suggested, but these usually involve high-value feedstocks and fail to make economic sense without large subsidies. One is the production of ethanol from agricultural crops, as practised currently in the widely publicized alcohol fuels programs of the United States and Brazil. Crops in Canada generally have more value as a food or feed source than as an energy source. Even low value wheat at $2.50 a bushel would cost about 35¢ a litre converted to ethanol, assuming the availability of cheap process energy and ready access to fuel and by-product markets. This is twice the current cost of gasoline from tar sands, but another 500 million litres of ethanol could be available in Canada at these prices by 1990. From prime wheat at $4.00 a bushel, the cost of ethanol would exceed 50¢ a litre, or nearly three times the cost of imported oil.

The energy considerations in making ethanol from high value crops may be unfavourable as well. With modern technology, the energy in fossil fuels required to grow and process the crops will be at least as great as the energy

contained in the ethanol and by-products. If this input energy is primarily supplied from oil products, ethanol production for fuel use could actually increase oil imports. Ideally, as much of the energy as possible would be supplied from coal and natural gas, but one-third of it will almost inevitably remain oil-derived.

Ethylene is also a high-value feedstock, but as a source for ethanol in Canada it makes more economic sense at present than agricultural crops. Ethylene might earn up to 20¢ a pound as an export commodity. At this value, the cost of ethanol would be 30¢ a litre or about $50 a barrel oil equivalent. It would not be impossible for Canada to build an additional (its third) ethylene plant by 1990, and manufacture ethanol from surplus ethane. If a plant of this size were to direct its output to the fuel market, it could displace 22Mb/d of gasoline. This might be a surprising direction for the Canadian petrochemical industry to take, but no more so than fuels from food.

A third possibility may be the cheapest of all the ethanol options, but it is still at the development stage. Recent work has confirmed that ethanol can be the major product from the conversion of synthesis gas in a modified process. This could furnish "ethyl fuel" at the energy-equivalent cost of methanol, or about 20¢ a litre from coal.

Methanol

Methyl fuel, which consists of methanol with up to 25% of higher alcohols, is produced from synthesis gas. About 1,200 tonnes a day of methanol are produced in Canada for industrial markets both here and abroad, and several additional plants of this size are planned for the next few years to sell in growing world methanol markets. Current world trade is in chemical-grade methanol, not methyl fuel. Very small amounts of methanol are used world-wide for fuel purposes today. Unless methanol becomes accepted as a fuel, currently planned production capacity, especially in the middle east, is expected to saturate industrial methanol markets by the mid-1980s.

As a fuel, methanol does not enjoy the same compatibility with gasoline as ethanol does. Blends of methyl fuel and gasoline will separate into two phases unless conditions are met that may be unrealistic in Canada. Furthermore, some driveability problems might be experienced in vehicle operation with methyl fuel blends, penalties that would not be acceptable to Canadian motorists except under emergency conditions. Very low methyl blends (less than 4%) may be less of a problem but are not welcomed by refiners because the methanol displaces butanes, which the refiners currently blend with gasoline and which are in surplus supply. As noted earlier, the problems might be avoided by converting methanol to gasoline-compatible ethers through reactions with refinery by-products (olefins); however, there is a limit to the availability of olefins for this purpose.

Methyl fuel is best used as a sole fuel, in circumstances where its incompatibility with the oil products distribution and storage systems is not of concern. Examples are centrally-fueled vehicle fleets, commercial boilers and turbines and domestic home heating. Because methanol is a hazardous and toxic chemical, special provisions would be needed to ensure safety in its handling and storage. One attractive feature of methanol in domestic heating could be its ability to extend the burning time and improve the efficiency of furnaces in smaller, well-insulated houses because of its lower energy content. Methanol may also be attractive as a utility fuel in communities not served by natural gas.

In vehicle fleets with special engines, methanol is an excellent fuel once the engine has warmed up, assuming it managed to start. Engines on methyl fuel will not start below 9°C. Addition of 12% gasoline permits starting down to −10°C. Modifications to make an engine compatible with methanol are numerous but not difficult if incorporated into the engine production process. One estimate of the cost premium for a methanol engine is $500. Retrofit of existing engines for methanol operation is not considered practical except for experimental work.

As a vehicle fuel, between 1.5 and 1.8 litres of methyl fuel are required to displace one litre of gasoline, depending on the compression ratio of the methanol engine and the fuel efficiency of the comparative gasoline engine. For an optimized methanol engine compared to a gasoline engine capable of meeting the 1983 fuel economy standards, the appropriate ratio for the volumes of methanol and gasoline required to do the same work might be about 1.7:1.0.

The contribution of methyl fuel in Canada depends on the success of the fuel in penetrating selected markets. It is use-limited rather than supply-limited. Methyl fuel is likely to be made and marketed first in regions of the country where feedstocks for synthesis gas exist (natural gas, coal, peat, biomass) and where the lack of conventional liquid fuel production opportunities confers a premium value on alternative fuels. In these regions it is estimated that provincial support for methyl fuel could succeed in displacing 25 Mb/d of gasoline from vehicle fleets or fuel oil from stationary uses by 1990. A much greater penetration of methanol than this is certainly possible but would require a major Government commitment to the fuel and the infrastructure required to deliver and use it.

The cost of the methyl fuel options depends on the source of the fuel and the costs of distribution. Methyl fuel might be made from expensive coal in British Columbia, Saskatchewan or Ontario for about 12¢ a litre, and at a slightly higher cost in Ontario. Its cost from wood and wood wastes in British Columbia, Ontario or Quebec would be more, at least 15¢ a litre, except in a few special situations. It might also be made in the Atlantic provinces by

combining coal and wood resources, but at considerable cost. The cost of producing methyl fuel from natural gas depends on the value of the gas. Assuming an economic value of $4/Mcf, methanol made in Alberta would "cost" 16¢ a litre using existing Canadian technology. At an Ontario location where gas is more costly, this plant could produce methanol for about 17¢ a litre. Natural gas is an expensive feedstock for methyl fuel because a relatively inefficient conversion of a high value energy resource is involved. A more efficient way to use natural gas in methyl fuel production may be as a joint feedstock with hydrogen-deficient resources such as coal, wood and peat.

Because of our enormous supply potential, Canada could become a world leader in the technology of methanol production and use. Domestic methanol production for export might be attractive for the near term as it would combine high value current markets with the contingency value of a chemical that could be diverted to fuel markets on short notice. Coal that is inexpensive to mine in Canada would be a particularly attractive source of methanol costing about $28 a barrel oil equivalent. If low value resources of wood, peat or gas can be produced or found, they may also be economic feedstocks for methanol at costs between $30 and $40 a barrel oil equivalent.

Natural Gas in Vehicles—Compressed or Liquefied

Natural gas can be used directly as transport fuel, avoiding the inefficiency of conversion to methanol or gasoline. One way is to compress the gas for on-board vehicle storage in high pressure tanks. Compressed natural gas (CNG) can be used in vehicles with advantages similar to propane—it is a clean-burning and efficient fuel. Unlike propane, the supply of natural gas in Canada is considerable, and the opportunity exists, in theory at least, to displace most of our transport fuels with natural gas for many years to come. Vehicle storage tanks would be heavier and bulkier than those required to store propane, and vehicle range would be limited. This may not be a major problem for certain truck fleets. Vehicle conversion costs would be at least $1,500, somewhat higher than for propane, and in addition a compressor station would be required to fill the tanks. Because of this requirement the use of CNG in the near term in Canada would be attractive primarily for large fleets of vehicles.

If natural gas is valued at $4/Mcf (Alberta border), the cost of displacing diesel oil or gasoline in Ontario including compression and conversion costs for large fleets would be about $25 a barrel oil equivalent.

Liquified natural gas (LNG) is much more difficult to handle than CNG, and its use in vehicles would appear to raise a number of safety concerns. LNG might be suitable as a fuel for other modes of transport such as ships and trains.

Hydrogen as a Transport Fuel

The use of hydrogen in engines has been demonstrated around the world, and continues to capture the imagination of both scientists and laymen as the perfect or "ultimate" fuel. Hydrogen might eventually assume this auspicious identity, but probably not for many decades to come. There are three practical problems that impede the use of hydrogen as a transport fuel in this century, except possibly in the premium jet fuel market where its exceptionally high energy-to-weight ratio gives it an advantage on aircraft. The first problem with hydrogen is its very high cost of production, whether from natural gas, coal or the electrolysis of water. The major reason for the high cost is poor conversion efficiency. The energy in the hydrogen is much less than the energy in the feedstock. The second problem is distribution and storage. Compared to natural gas, which is already distributed in Canada and which can be stored on vehicles with modest penalties for tank weight and vehicle range, hydrogen is at a substantial disadvantage.

The third problem for hydrogen fuel is that it may have more value as a feedstock for upgrading other energy resources to liquid form than as a fuel itself. Hydrogen is the key energy input in synthetic fuels manufacture and upgrading, and the cost of most new fuel options depends critically upon how the hydrogen is produced and how effectively it is used. Indeed, most of the new fuels discussed in this paper represent ways to store and carry hydrogen energy in chemical combination with carbon, ways that are more energy-efficient than the hydrogen storage technology developed to date.

SUMMARY OF CONTRIBUTIONS AND MAJOR BARRIERS

Possible Contributions from Liquid Fuel Options

Table 1 lists the fuel options discussed in this paper in a comparative presentation. It has been emphasized that there are many bases for comparing options; some options involve local resources whose supply is secure, some bring attractive employment benefits, and some have environmental disadvantages. One important measure for comparison is the cost to Canada of the fuel that is produced or made available by the option. These costs vary widely and depend on many assumptions. Table 1 provides a likely range of costs for each option, expressed in 1980 dollars per barrel of the extra crude oil or the new fuel (crude oil equivalent) that the option generates.

As seen in Table 1, about 500 Mb/d extra barrels of oil or equivalent fuels could be generated by 1990 at prices up to $50 a barrel if all options were to be pursued. The contribution shown for each option is an estimate of what could be accomplished through vigorous commercial action with modest Government encouragement. In a number of cases, the contributions could be greater than the figures shown in Table 1 if the Government were prepared to intervene in a major way in the fuels and vehicle industries.

The value of Table 1 may be that it suggests an economic perspective for viewing liquid fuel options. The costs in the table represent a social rather than commercial calculation, and are only estimates; in most cases sufficient technical and economic work has not been done to predict accurately the cost of fuels that are still a number of years away from production. But the figures can help us organize the options and the arguments for pursuing them. Costs are important because Canada is not short of energy and will not become so in the foreseeable future. We are short of liquid fuels, and we must focus our attention on how to rectify that imbalance with the greatest social and economic advantage. It may be useful to group the options in Table 1 into categories of economic attractiveness.

It was emphasized at the beginning of the paper that the most attractive measures may very well be ones that hardly appear in Table 1 at all. It is generally agreed that ways to reduce the *requirements* for liquid fuels, through energy conservation and through substitution of non-liquid fuels for oil, continue to represent the cheapest paths to energy security. The federal government is firmly committed to major policy initiatives in these areas. The work on engine development listed in Table 1 involves energy conservation to a considerable extent, since part of the work is directed at more efficient engines. As well, the work involves the development of fuel-tolerant engines. Engine development work is extremely important to the future of vehicles and fuels in

Table 1. ***Liquid Fuel Options***

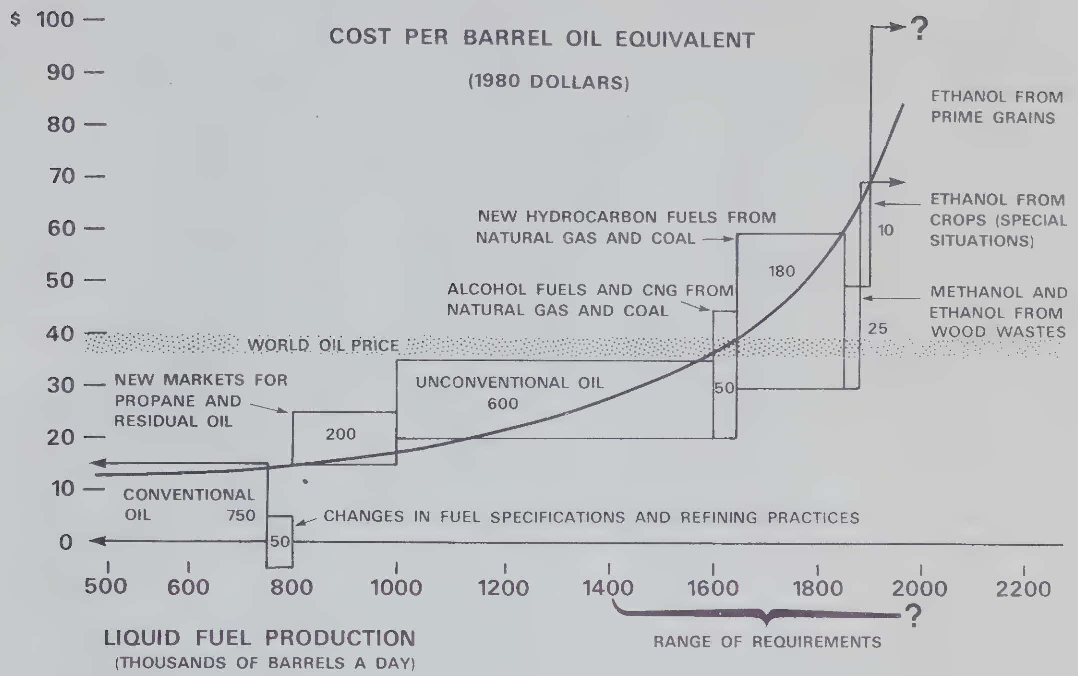
Option and Source	*Range of Cost/Barrel Oil Equivalent*	*Possible Contribution in 1990*	*Limiting Factors*
	($)	(Mb/d)	
Propane in vehicles	20–25	60	Vehicle conversion
Residual oil upgrading	18–22	140	
Changes in fuel specifications	no extra cost	40	Engine specifications
Engine development	?	10	
Fischer-Tropsch liquids			
Coal	40–65	60	
Mobil Gasoline			
Coal	40–55	30	Technology
Remote gas	40–50	30	Supply of gas
Pipeline gas	60–65	–	Uneconomic
Direct coal liquids	30–40	60	Technology
Ethanol			
Wastes	40–50	8	Supply of wastes
Cellulosics	?	5	Cost
Crops	50–90	10	Mostly uneconomic
Ethylene	45–55	22	Supply of ethane
Coal synthesis	30–40	?	Technology
Methyl fuel			
Coal	25–35	13	Markets
Wood	30–40	12	Markets
Pipeline gas	40–45	–	
Compressed natural gas	22–25	15	Large fleets
Total		515	

Canada and the United States. Its near-term contribution, estimated at 10 Mb/d for 1990 in Table 1, is comparatively small because of the time required for new engine technology to penetrate vehicle markets.

The total requirements for liquid fuels in Canada in 1990 will depend on how successfully the nation is able to organize and respond to conservation practices and opportunities for substitution away from liquid fuels. Estimates of

FIGURE 2

LIQUID FUEL OPTIONS FOR 1990



future liquid fuel requirements vary widely for this reason, as shown at the bottom of Figure 2. This graph focuses on the gap between this range of requirements and conventional oil supplies; this is the gap that our fuel options will have to fill if Canada is to eliminate oil imports. Figure 2 organizes the options into categories or groups, and shows how they could be developed to augment our supplies of conventional oil. A projection of 750 Mb/d, based on the National Energy Board report issued in 1978, is used to illustrate the size of the conventional oil base in 1990, including established reserves and reserve additions.

The least costly group of options are the adjustments in the refining and marketing of current petroleum fuels. There are many opportunities here, and only three examples were discussed in this paper: new markets for propane, new markets for residual oil through upgrading, and changes in the manufacture and specification of transport fuels. These represent inexpensive ways to add modest amounts to domestic liquid fuel supply and are shown in Figure 2 as two blocks of 50 and 200 Mb/d. They range in cost from virtually free to about $25 a barrel. Most of these options are economic or close to economic at current oil prices in Canada, and need relatively little Government encouragement to initiate.

The second group of options is unconventional oil, and involves the production of fuels from Canada's vast reserves of tar sands bitumen, heavy oils and frontier oil. Canada appears to have sufficient reserves of these low-grade or remote petroleum resources to furnish adequate liquid fuels for several centuries at current rates of use. However, some of the reserves may be quite expensive to recover, particularly bitumen that is too deep to mine and has to be upgraded in situ. Currently Canada has proven technology to mine and upgrade surface tar sands and to recover and upgrade certain heavy oils at prices between $20 and $32 a barrel (1980 dollars), prices that are expected to remain below the world price of oil. The National Energy Board has estimated that 600 Mb/d of unconventional oil could be produced in 1990 with proven technology.

These large petroleum reserves make us the envy of other oil-consuming nations. They promise to give Canada a competitive advantage in the world trade in liquid fuels, an advantage we may wish to exploit once we have built the capacity to fully satisfy our domestic liquid fuel requirements. From the vantage point of 1980, there are problems with this group of options. One is that the speed of development is limited. The growth rate of the Alberta tar sands industry could be close to the maximum development schedule and is already putting a great deal of pressure on the technical, financial and manpower resources of the province and the nation. Another problem may arise in the refining changes that will be needed as synthetic crudes from bitumen begin to account for a significant fraction of crude oil deliveries to Canadian refineries.

The third group of options could be considered our "security-of-supply" group: options that are technically feasible today and that could provide us with a secure alternative source of liquid fuels, if we were prepare to attach a strategic importance to that goal. These options involve the use of natural gas and coal, which are fossil fuels currently in surplus supply, to provide liquid fuels or "near-liquids" through proven technology. They include the synthesis of liquids such as gasoline, diesel and heating oil, alcohols and LPGs from coal and natural gas, the direct liquefaction of coal, and the direct use of natural gas as a vehicle fuel (CNG). They are probably all less attractive than unconventional oil for one of two reasons:

- They may be more expensive than unconventional oil. This appears to be true for hydrocarbon liquids from coal or gas via Fischer-Tropsch synthesis or the Mobil process, for methyl fuel from natural gas, and for ethanol from ethane via ethylene, all of which are in the $40–$60 a barrel range. It will probably be true as well for direct coal liquids, although this technology is not yet proven. Coal is cheaper than bitumen to mine, but it is expected to be more expensive to upgrade.
- The cost of the fuel ($20–$40 a barrel range) may be below unconventional oil, but its use would involve some disruption and change in fuel distribution systems and vehicle technology and performance. Methyl fuel from coal and CNG belong here.

The fourth group of options involves the conversion of biomass resources (agricultural and forest resources and wastes) to alcohol fuels (methanol, ethanol and higher alcohols). Biomass resources tend to be expensive feedstocks for liquid fuel production because they do not have a high energy density, are dispersed in occurrence, and may have considerable value in non-energy uses (food, fibre, chemical). These characteristics raise the price of the liquid product because of high processing costs, high feedstock collection costs and a high "opportunity value" for the feedstock. The result is that alcohols from biomass suffer two disadvantages as a fuel: they are more expensive than liquids from fossil sources, and their use in a predominantly hydrocarbon fuel system presents certain difficulties and requires adjustment.

However, alcohol fuels from biomass have some offsetting advantages that make the fourth group of options attractive to Canada. Biomass resources are more evenly distributed regionally in Canada than fossil resources, permitting some provinces that are relatively poor in fossil fuels to build a small base of liquid fuels production on biomass. This option would help spread the social, financial and environmental impacts of energy development, which today are concentrated in western Canada. As well, biomass resources are renewable, and unlike coal, natural gas and oil, they are not depleted through use. Because they will be with us forever, some direct experience in their varied use as energy sources would be of lasting value to Canada. Another advantage might be that the scale and impact of biomass conversion tends to be less than the more intensive processing of fossil resources. These advantages indicate that a modest contribution of both ethanol and methanol from lower-value biomass resources, especially waste materials, might be welcome in Canada during the next 10 years, at costs between $30 and $50 a barrel oil equivalent. At higher prices, small quantities of ethanol from crops might be produced in particular regions of the country where express local support has developed for this use of crops and agricultural land.

Market Barriers

Government action to encourage fuel options should take aim at the particular difficulties or barriers that the option faces. Many of the options discussed in this paper face a market barrier: it costs more to produce and deliver the fuel than the market is prepared to pay. There may be several reasons that the fuel appears to be too expensive. For example, with price controls on oil and gas it is possible that alternative sources of fuel that are economic may remain unexploited. The federal government is anxious that this not happen and is committed to encourage alternative fuels. It welcomes ideas for Government action and is prepared to provide support. The recent announcement that the federal government will establish a Crown corporation to promote alternative energy in Canada is one major step in this direction. Other instruments are under study.

Once programs of federal support are better developed, some fuel options may still remain uncompetitive. This could be the result of high feedstock and production costs, as for alcohol fuels, or high transportation and distribution costs, as for LPGs in certain regions of the country. In these cases, the support of provincial governments would be valuable and might have particular appeal as a means to accelerate progress towards energy security, and to diversify our liquid fuels resource base or the regional base of production.

Some provinces have already provided support for resources or fuels of special interest to them. For example, the Ontario government has removed the provincial tax on alternative fuels. This subsidy makes propane cheaper than gasoline in Ontario. Manitoba has gone beyond the Ontario scheme in support of alcohol fuels. In the provincial budget on May 13, 1980, the Manitoba government provided a tax subsidy of about 40¢ a litre to ethanol in a 10% blend with gasoline. This very substantial subsidy promises to bring gasohol to Manitoba with no need for complementary federal support.

Technical Barriers

For certain options there are technical barriers as well as market barriers. If the market signals are right, resource owners, fuel refiners and vehicle manufacturers may be expected to perform the research and development needed to reduce the technical risk. In many cases this work has already begun. But commercial investment may be delayed until the technical risk becomes tolerable, and the delay could be quite expensive for the nation. Moreover, investment funds tend to flow to options of lower technical risk, ignoring higher risk opportunities that may end up to be more profitable.

The Government can accelerate the commercial date of certain options by directing and contributing to research and development work. In addition, it can steer investment to higher risk options through Crown participation in selected demonstrations or “first commercial plants”. The federal government has begun to identify priorities in research, development and demonstration needed to support fuel options, and it is seeking the co-operation of provincial governments and industry to determine where current work fails to reflect these priorities.

In moving to fill the gaps in research, development and demonstration, the Government should distinguish the level of research adequate to provide itself with policy advice in the fuels area from the practical work needed to ready an opportunity for commercial development. The latter work is often best performed outside of the government sector, but it may be desirable to provide some support for this work to the industries likely to be involved in the commercial activities. A major increase in funding for research and development is currently being sought.

Other Barriers

There may be other barriers, such as industrial inertia, regulatory distortion or inadequacies, and consumer attitudes, that could become apparent once efforts had begun to remove market and technical barriers to new liquid fuels. These might require further Government action. Some regulatory improvements are currently being studied, such as the provision of specifications for certain new fuels, and the improvement of test methods and standards to regulate safety and health problems in fuel handling and vehicle operation. Another barrier, the bonding requirement for a licence to distill alcohol fuels, is being considered by Revenue Canada. As well, limiting environmental factors will need to be identified and fully considered before any substantial development of new fuel options occurs.

The federal government is anxious to encourage discussion in Canada on the value of new fuel options to the country over the coming two decades, and on ways that federal and provincial governments, industry and the public can work together to learn more about the options and to remove the barriers to those which appear attractive. It is hoped that the information and ideas in this brief presentation of some of our liquid fuel opportunities will encourage and assist those discussions.